Mesospheric Response to Impacting Relativistic Electrons

Bi-Annual Progress Report #1

Period: 21 July 1995 through 1 February 1996

Contract P.O. S-57779-F

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Introduction

The Space Sciences Laboratory (O/91-20) of the Lockheed-Martin Missiles and Space Company's Advanced Technology Center (LMMS/ATC) is supporting Dr. Richard Goldberg of the NASA Goddard Space Flight Center in a scientific investigation of the effects of relativistic electron precipitation on the chemical composition and dynamics of the mesosphere. This is the first bi-annual progress report of the effort produced at LMMS in this collaboration.

During the initial phases of this effort most of the resources provided by the purchase order were used to support the efforts of Mr. Edward E. Gaines in the reduction and analysis of the electron data from the PEM/HEPS instrument aboard UARS. As a result, the bulk of this report consists of Mr. Gaines's reports of his progress and results. They are attached as Appendices A and B.

Progress

During the first 6-month period of the effort under this purchase order tasks 1 and 2 of the "Statement of Work" have been addressed and substantially completed by Mr. Gaines.

Task 1 of this project is to "identify periods of relativistic electron precipitation" and to help select "specific events for more detailed analysis". Appendix A presents the initial results obtained under this task. Plots of the daily electron intensity observed aboard UARS are provided for the period from October 1991 through mid-1995. The largest events have been identified and listed in the Table attached to the end of the appendix. As a result of this task, the first priority intervals for analysis are: 11 - 21 May 1992, 10 - 20 October 1991, 24 November - 21 December 1991, 4 - 8 November 1991, and 6 April - 3 May 1993. These intervals have been discussed with Dr. Goldberg. We have agreed to continue to focus most of the attention on the 11-21 May 1992 interval.

Task 2 of the project is to "Provide energy spectra, spatial and temporal distributions of relativistic electron precipitation ... for the events identified in Task 1." Relativistic electron energy spectra are presented in the attached Appendix B, as provided by Mr. Gaines, for the November 1991, December 1991, and in detail for the May 1992 periods. Indications of the temporal and spatial variations of the precipitating electron intensity are provided with samples obtained at different places and times within each event period. During the May 1992 event, results are provided for each day. Finally, the precipitated electron flux intensities and energy spectra are used to calculate altitude profiles of ion production rates throughout the mesosphere for each interval. Plots of these profiles are also provided in Appendix B.

These results have been provided informally to Dr. Goldberg and discussed with him during meetings at Lockheed in December 1995 and March 1996. As one result of these discussions we have agreed to produce maps of precipitating electron intensity for each day of the May 1992 period. These will be provided when ready and will be incorporated in the next bi-annual report.

Appendix A

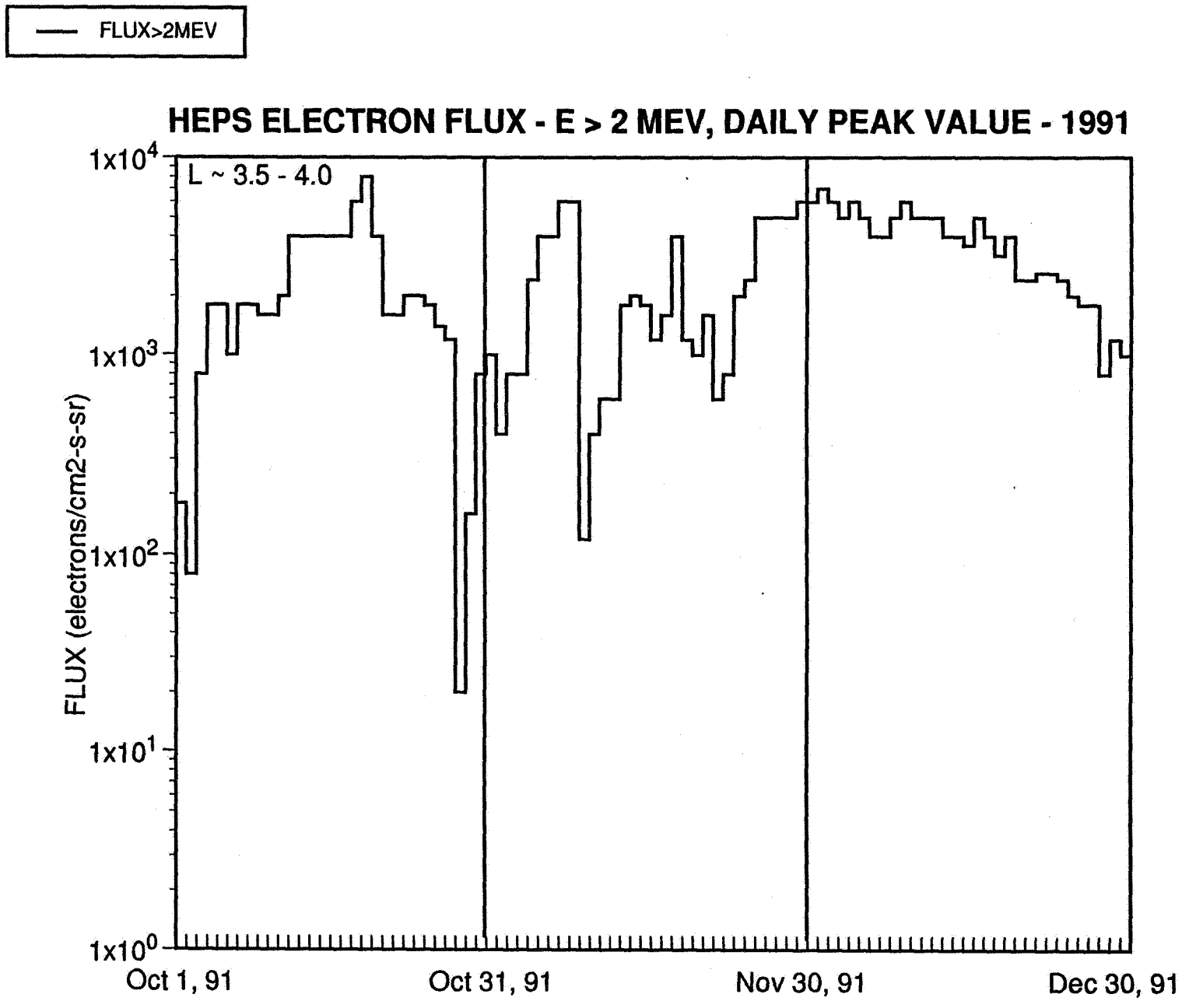
30 Nov. 1995

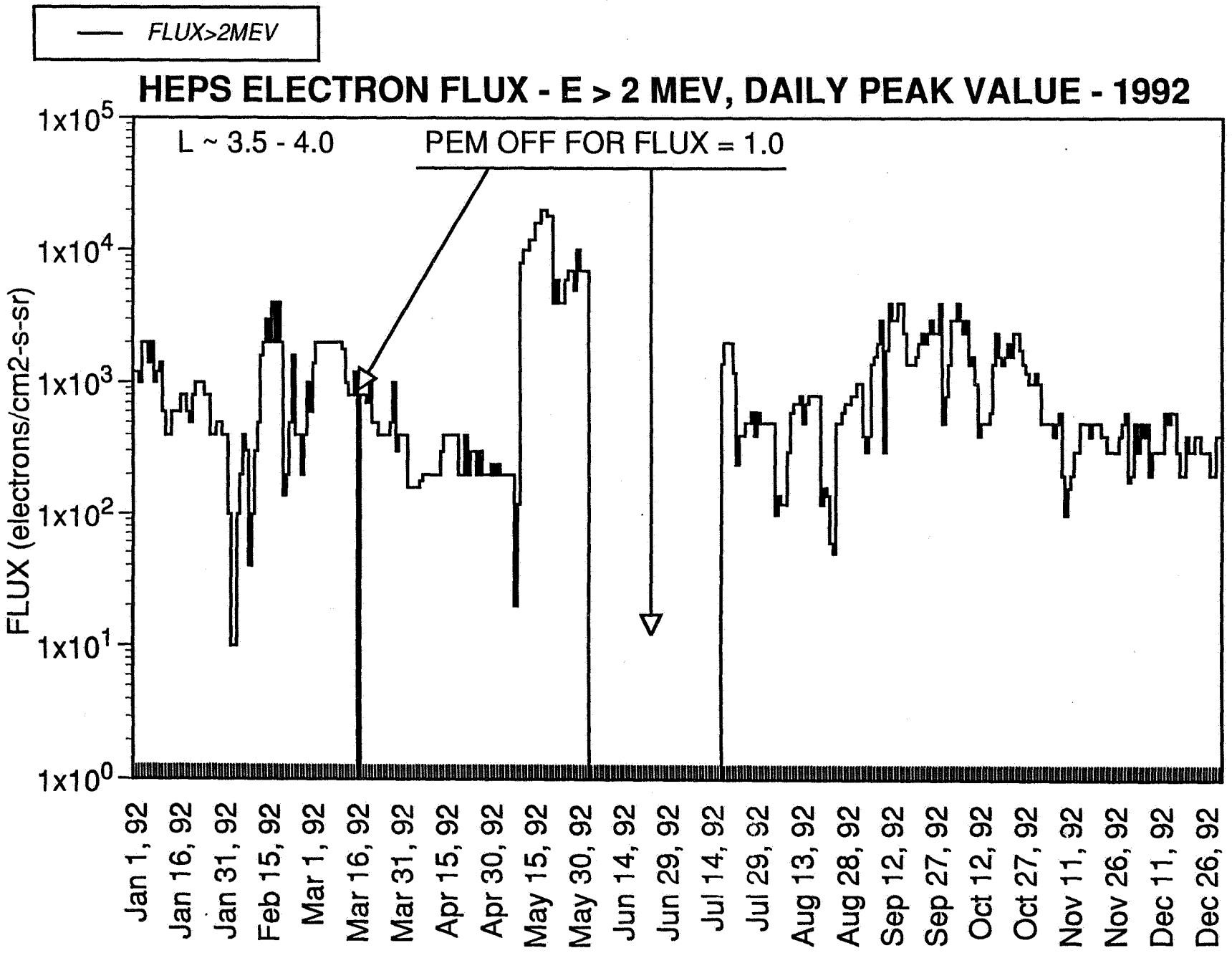
Interim Report - Mesospheric Response to Impacting Relativistic Electrons : Task 1. Ref P.O. SC TDZ0930 F

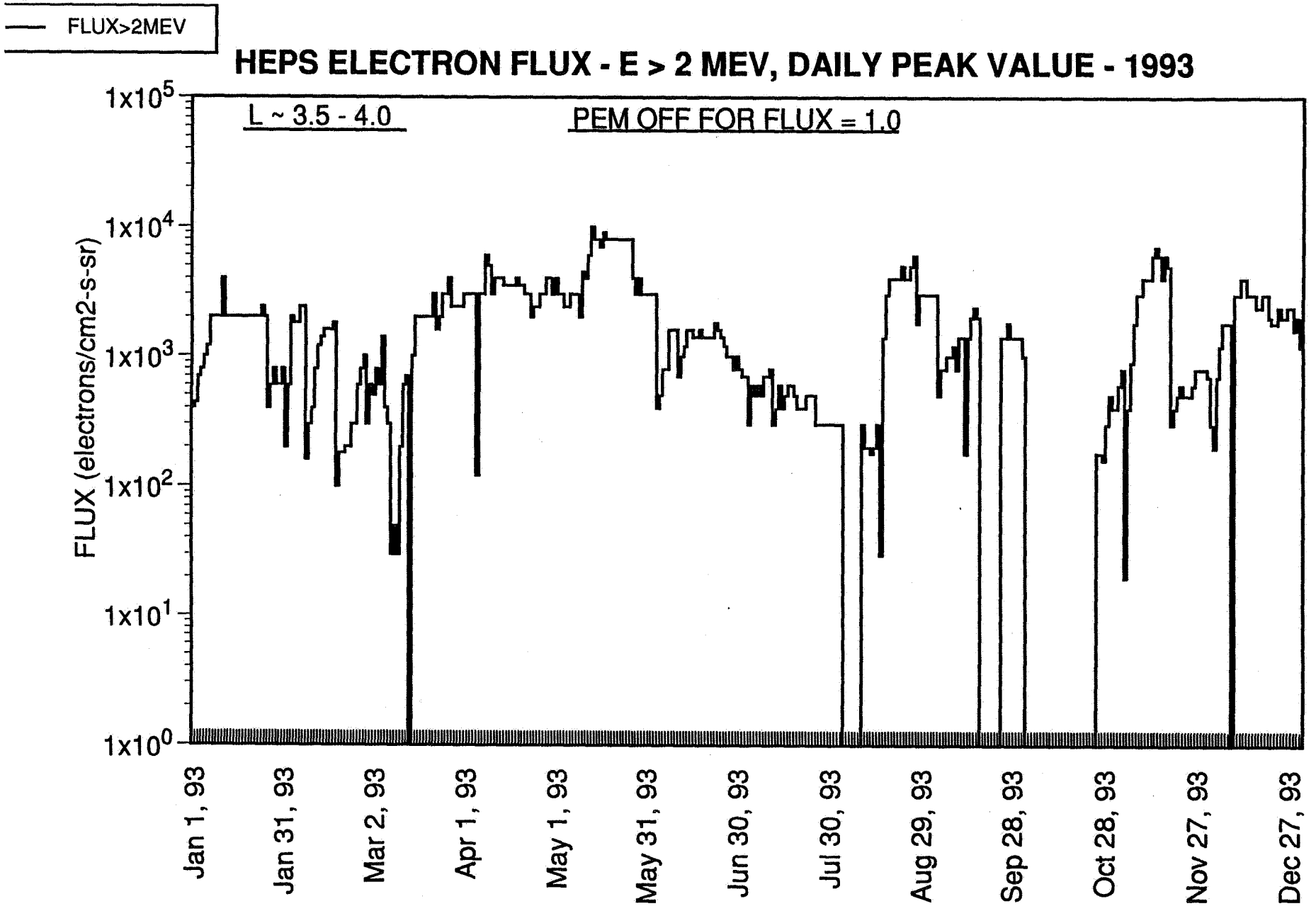
Submitted in completion of Task 1 of SPACERAD statement of work:
Using data from the PEM/HEPS instrument aboard the UARS spacecraft, periods of highly relativistic electron precipitation will be identified, and SPACERAD will join in the selection of specific periods for more detailed analysis.

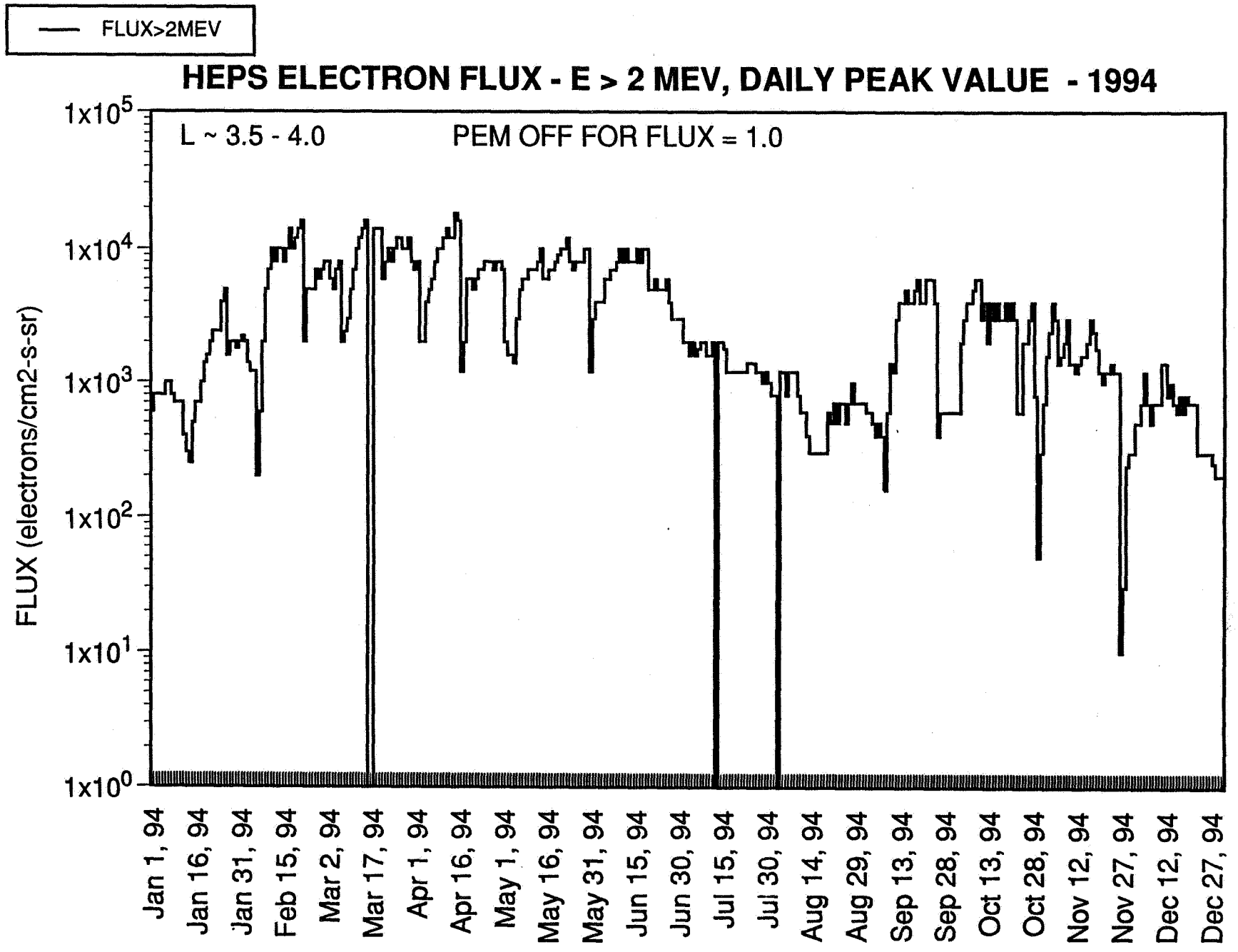
The intensity of relativistic electron fluxes at the UARS spacecraft has been extracted for the time period from instrument turn-on to mid-April 1995 when continuous operation of the HEPS was interrupted due to spacecraft difficulties. Plots of the peak daily flux of electrons with energies greater than 2 MeV are attached.

From the plots, several periods of high electron flux intensity were selected for suggested study during the operational lifetime of the CLAES instrument with which correlations of electron precipitation are to be sought. A summary of these suggested intervals is also attached.


FLUX>2MEV
HEPS ELECTRON FLUX - E > 2 MEV, DAILY PEAK VALUE - 1991
L ~ 3.5 - 4.0
FLUX (electrons/cm2-s-sr)
1x10^4
1x10^3
1x10^2
1x10^1
1x10^0
Oct 1, 91
Oct 31, 91
Nov 30, 91
Dec 30, 91


FLUX>2MEV
HEPS ELECTRON FLUX - E > 2 MEV, DAILY PEAK VALUE - 1992
L ~ 3.5 - 4.0
PEM OFF FOR FLUX = 1.0
FLUX (electrons/cm2-s-sr)
1x10^5
1x10^4
1x10^3
1x10^2
1x10^1
1x10^0
Jan 1, 92
Jan 16, 92
Jan 31, 92
Feb 15, 92
Mar 1, 92
Mar 16, 92
Mar 31, 92
Apr 15, 92
Apr 30, 92
May 15, 92
May 30, 92
Jun 14, 92
Jun 29, 92
Jul 14, 92
Jul 29, 92
Aug 13, 92
Aug 28, 92
Sep 12, 92
Sep 27, 92
Oct 12, 92
Oct 27, 92
Nov 11, 92
Nov 26, 92
Dec 11, 92
Dec 26, 92


FLUX>2MEV
HEPS ELECTRON FLUX - E > 2 MEV, DAILY PEAK VALUE - 1993
L ~ 3.5 - 4.0
PEM OFF FOR FLUX = 1.0
FLUX (electrons/cm2-s-sr)
1x10^5
1x10^4
1x10^3
1x10^2
1x10^1
1x10^0
Jan 1, 93
Jan 31, 93
Mar 2, 93
Apr 1, 93
May 1, 93
May 31, 93
Jun 30, 93
Jul 30, 93
Aug 29, 93
Sep 28, 93
Oct 28, 93
Nov 27, 93
Dec 27, 93


FLUX>2MEV
HEPS ELECTRON FLUX - E > 2 MEV, DAILY PEAK VALUE - 1994
L ~ 3.5 - 4.0
PEM OFF FOR FLUX = 1.0
FLUX (electrons/cm2-s-sr)
1x10^5
1x10^4
1x10^3
1x10^2
1x10^1
1x10^0
Jan 1, 94
Jan 16, 94
Jan 31, 94
Feb 15, 94
Mar 2, 94
Mar 17, 94
Apr 1, 94
Apr 16, 94
May 1, 94
May 16, 94
May 31, 94
Jun 15, 94
Jun 30, 94
Jul 15, 94
Jul 30, 94
Aug 14, 94
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Sep 13, 94
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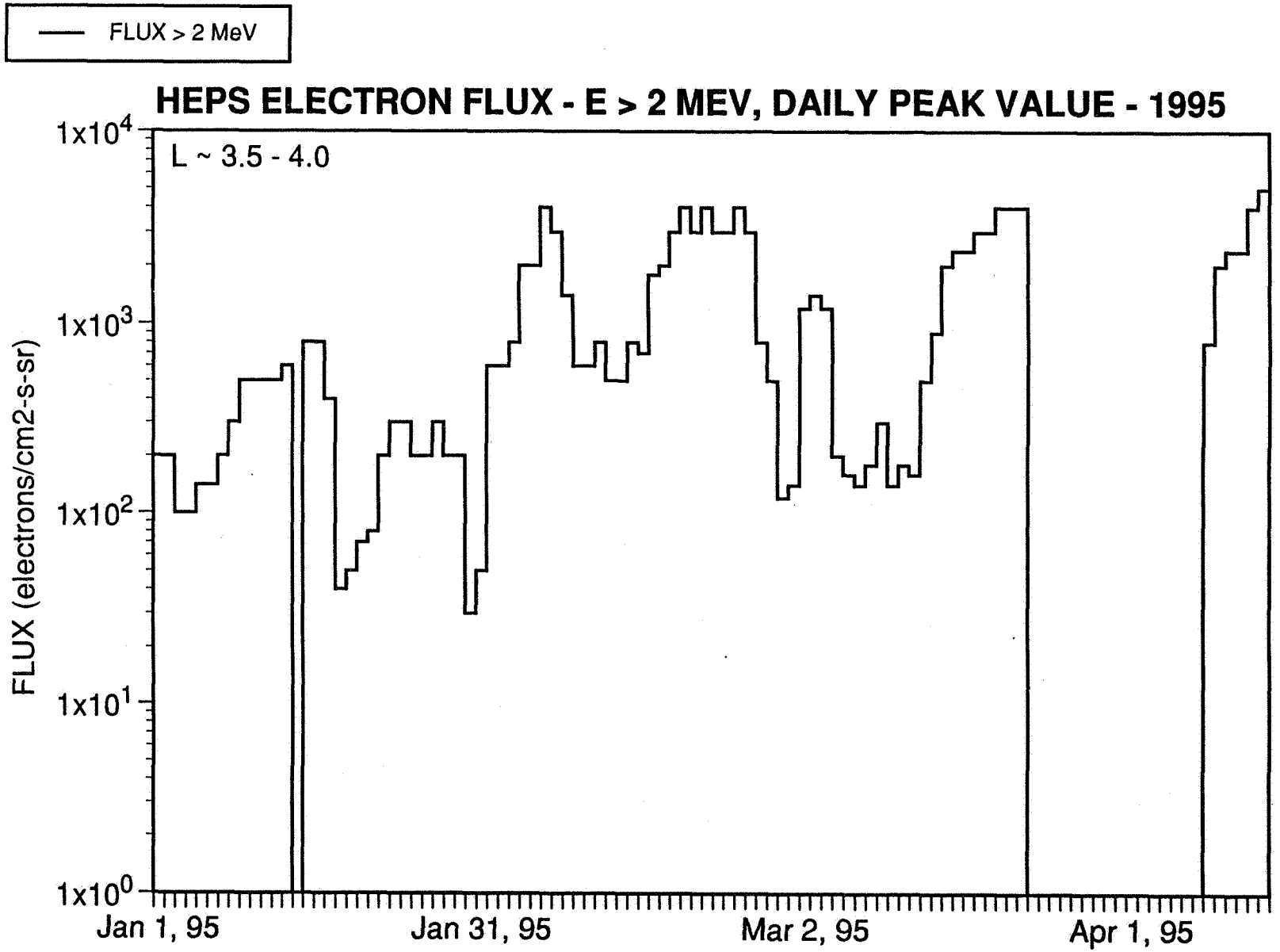
Oct 28, 94
Nov 12, 94
Nov 27, 94
Dec 12, 94
Dec 27, 94


FLUX > 2 MeV
HEPS ELECTRON FLUX - E > 2 MEV, DAILY PEAK VALUE - 1995
L ~ 3.5 - 4.0
FLUX (electrons/cm2-s-sr)
1x10^4
1x10^3
1x10^2
1x10^1
1x10^0
Jan 1, 95
Jan 31, 95
Mar 2, 95
Apr 1, 95

Mesospheric Response to Impacting Relativistic Electrons

SUGGESTED INTERVALS OF HRE FLUX FOR DETAILED STUDY

First priority - with CLAES data

DATE	UARS DAYS	PEAK > 2 MEV TRAP FLUX
1. May 11-21, 1992	243 - 253	2. X 10^4 / cm^2-s-sr.
2. Oct. 10-20, 1991	29 - 39	8. X 10^3
3. Nov. 24-Dec. 21, 1991	74 - 101	7. X 10^3
4. Nov. 4-8, 1991	54 - 58	6. X 10^3
5. Apr. 6-May 3, 1993	573 - 600	6. X 10^3

Appendix B

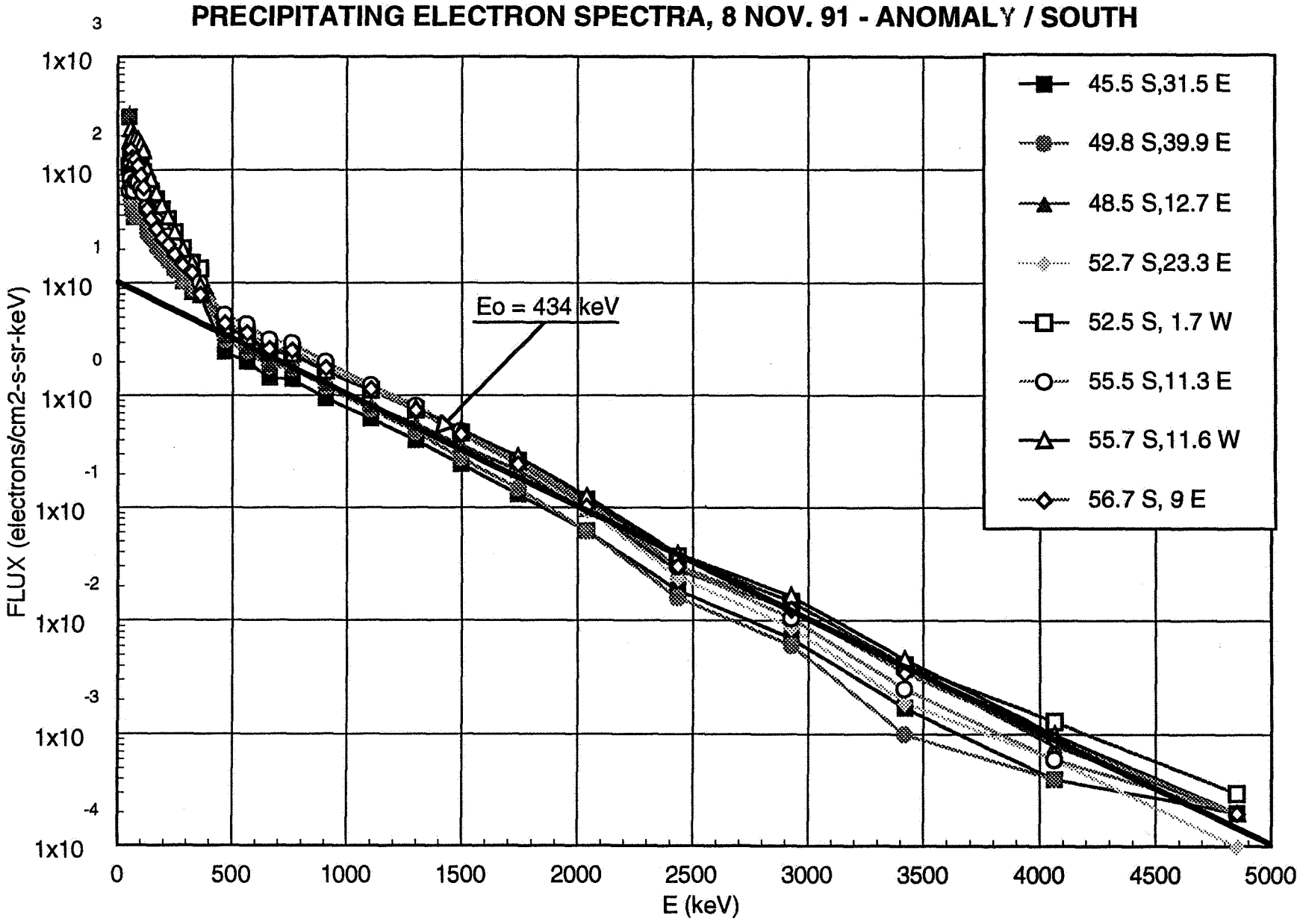
Interim Report

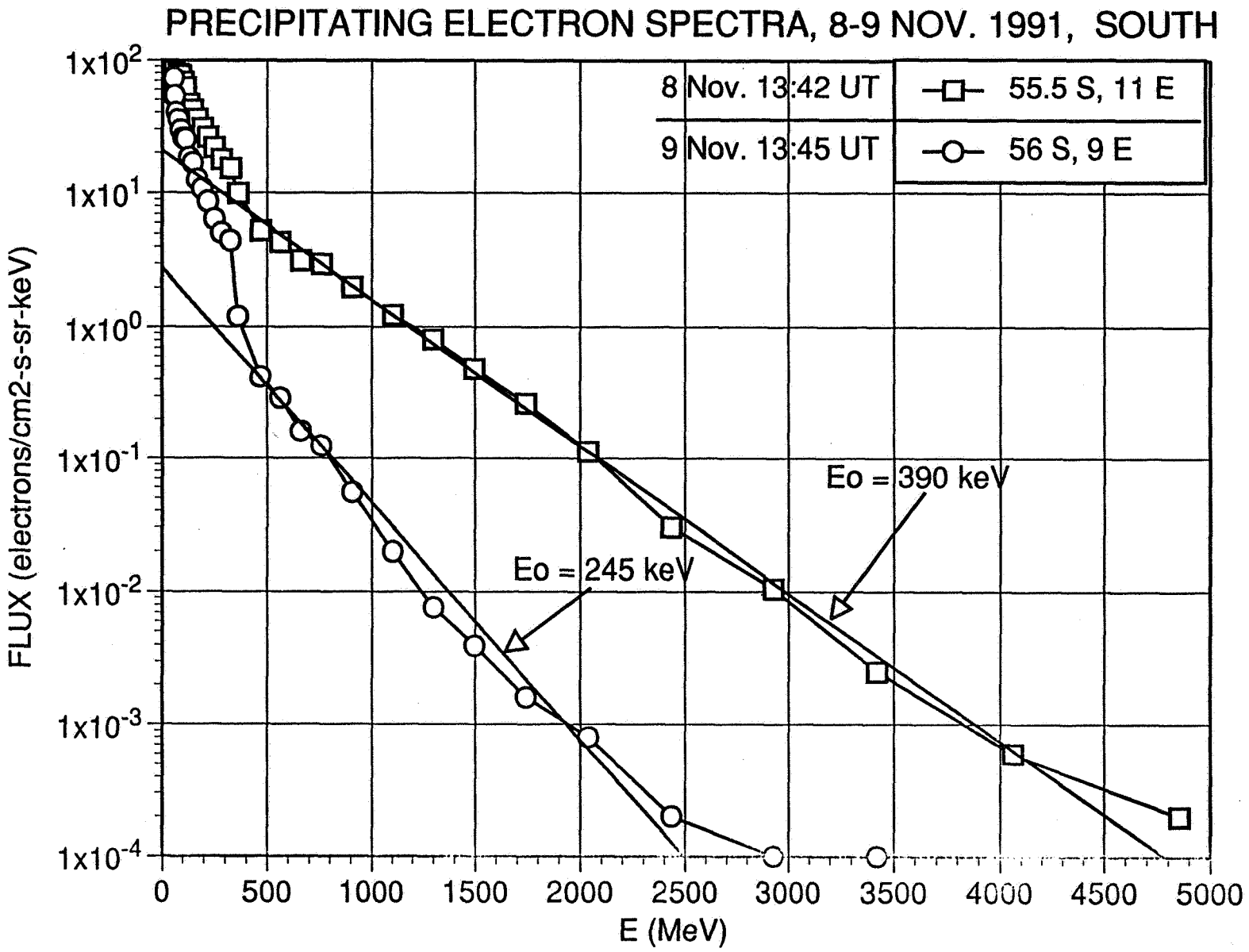
26 Feb. 1996

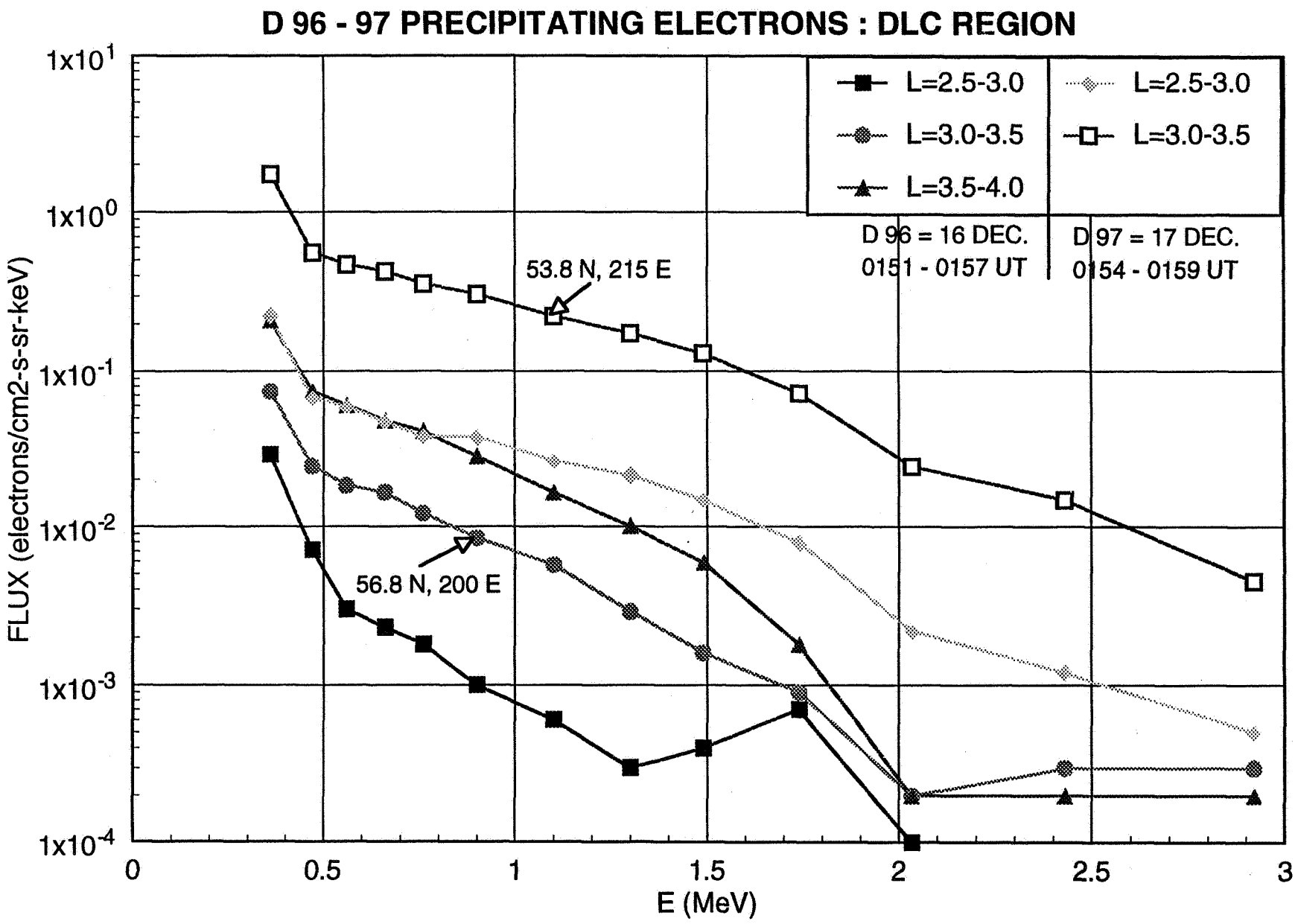
Task 2 in Statement of Work for support of project:
Mesospheric Response to Impacting Relativistic Electrons
Ref. P.O.# SC PDZ 0931F

Energy spectra, spatial and temporal distributions of precipitating relativistic electrons and resulting ion production profiles have been obtained from PEM/HEPS data in the time periods identified in Task 1 of this effort as most promising for correlation with measurements of ozone by other instruments on board the UARS spacecraft. These results have been transmitted to LMMS Dept. 91-20 and to Dr. R. A. Goldberg of NASA, and figures illustrating the measurements are attached herewith.

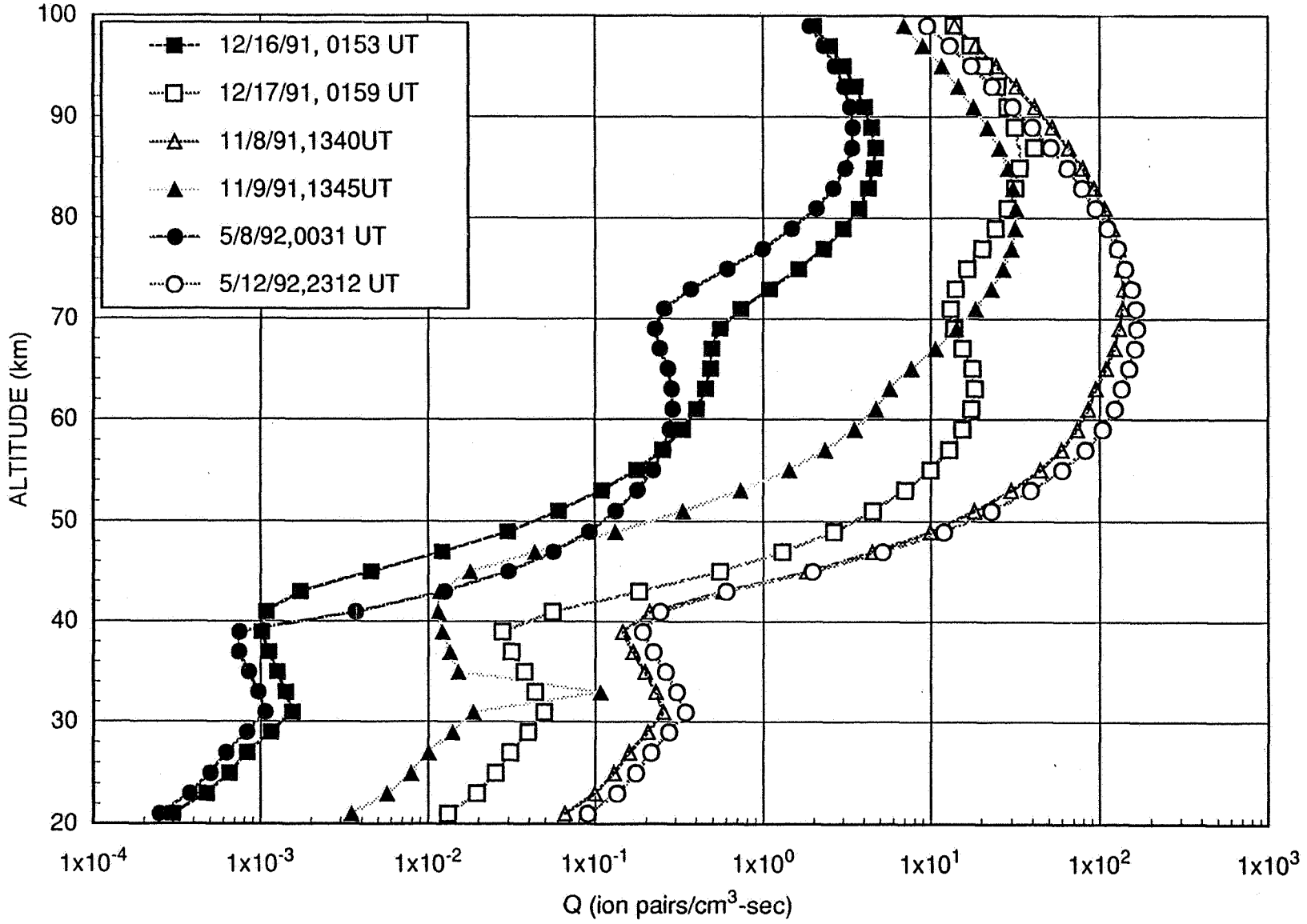
The periods for detailed analysis include the most intense fluxes of relativistic electrons observed wiht the HEPS instrument (May 12 - 20, 1992) and other periods with large changes in the fluxes of precipitating relativistic electrons within a few days. Times of both northward and southward observation by CLAES are included, but the magnetic local times of the flux observation periods were all between 0900 and 2000 hours.

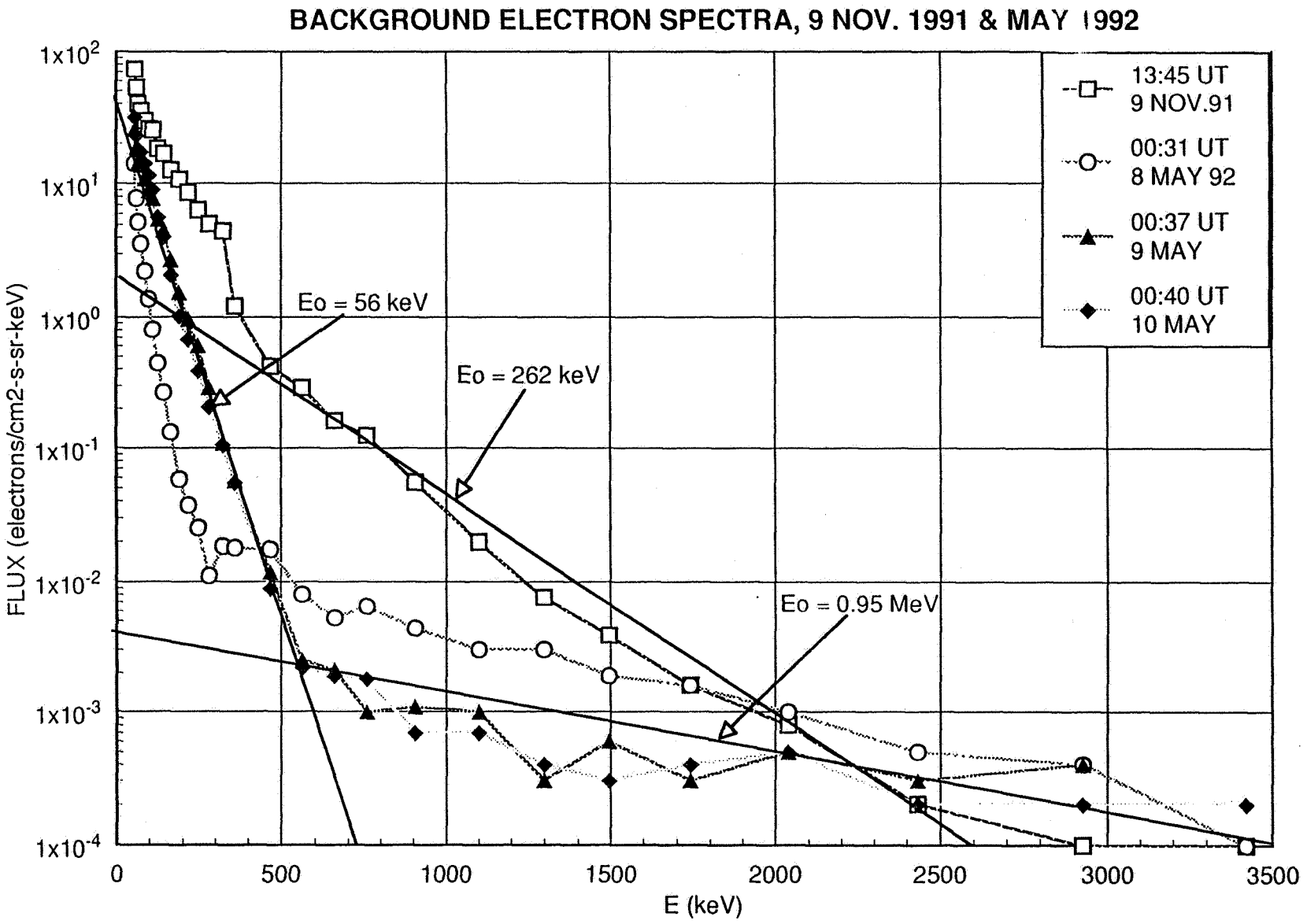

PRECIPITATING ELECTRON SPECTRA, 8 NOV. 91 - ANOMALY / SOUTH
FLUX (electrons/cm2-s-sr-keV)
3
1x10
2
1x10
1
1x10
0
1x10
-1
1x10
-2
1x10
-3
1x10
-4
1x10
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
E (keV)
Eo = 434 keV
45.5 S,31.5 E
49.8 S,39.9 E
48.5 S,12.7 E
52.7 S,23.3 E
52.5 S, 1.7 W
55.5 S,11.3 E
55.7 S,11.6 W
56.7 S, 9 E

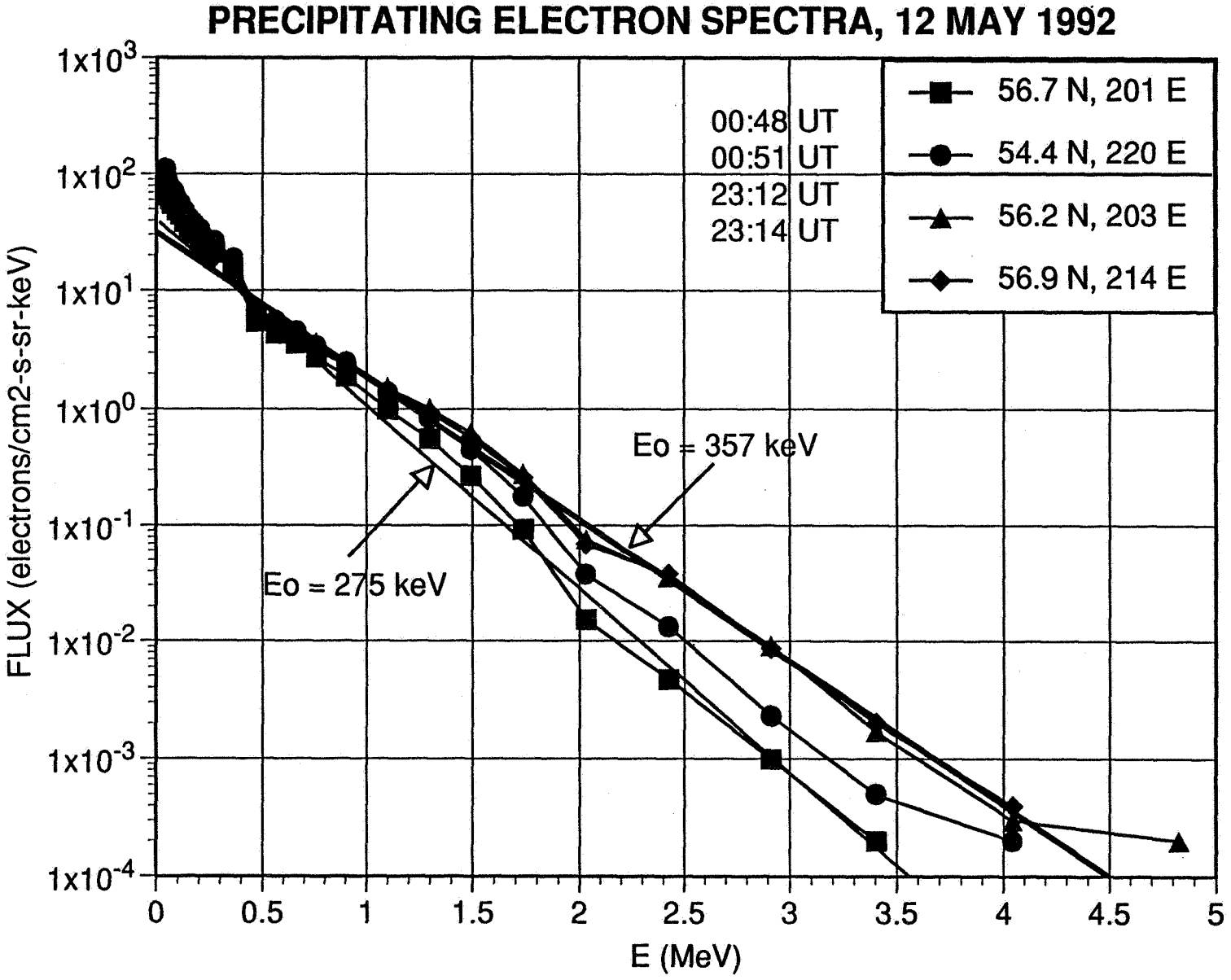

PRECIPITATING ELECTRON SPECTRA, 8-9 NOV. 1991, SOUTH
8 Nov. 13:42 UT
55.5 S, 11 E
9 Nov. 13:45 UT
56 S, 9 E
Eo = 390 keV
Eo = 245 keV
FLUX (electrons/cm2-s-sr-keV)
1x10^2
1x10^1
1x10^0
1x10^-1
1x10^-2
1x10^-3
1x10^-4
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
E (MeV)

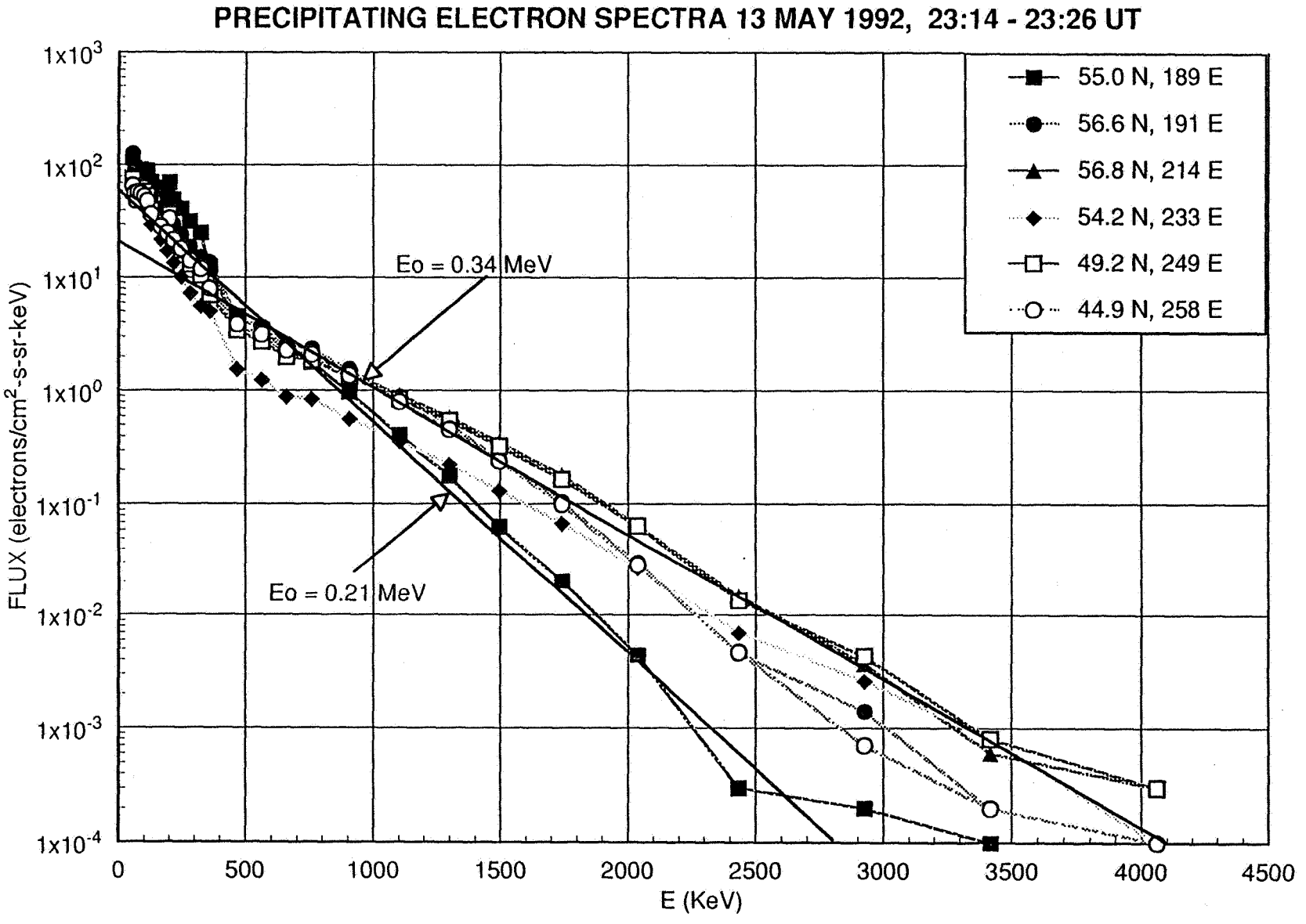

D 96 - 97 PRECIPITATING ELECTRONS : DLC REGION
FLUX (electrons/cm2-s-sr-keV)
1x10^1
1x10^0
1x10^-1
1x10^-2
1x10^-3
1x10^-4
0
0.5
1
1.5
2
2.5
3
E (MeV)
L=2.5-3.0
L=3.0-3.5
L=3.5-4.0
L=2.5-3.0
L=3.0-3.5
D 96 = 16 DEC.
0151 - 0157 UT
D 97 = 17 DEC.
0154 - 0159 UT
53.8 N, 215 E
56.8 N, 200 E

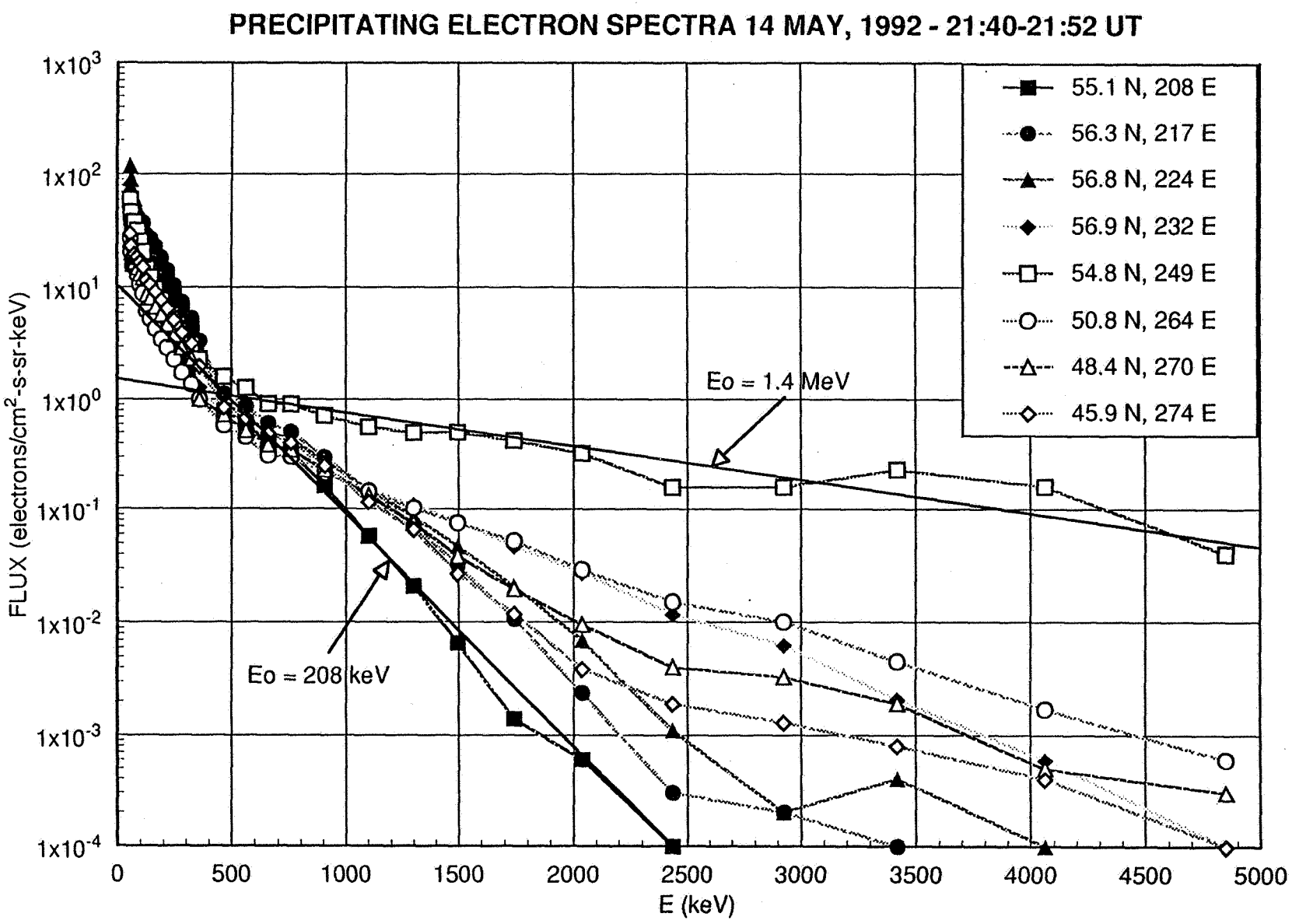
ION PRODUCTION PROFILES, 8 - 9 NOV. , 16 - 17 DEC. 1991, 8 &12 MAY 1992

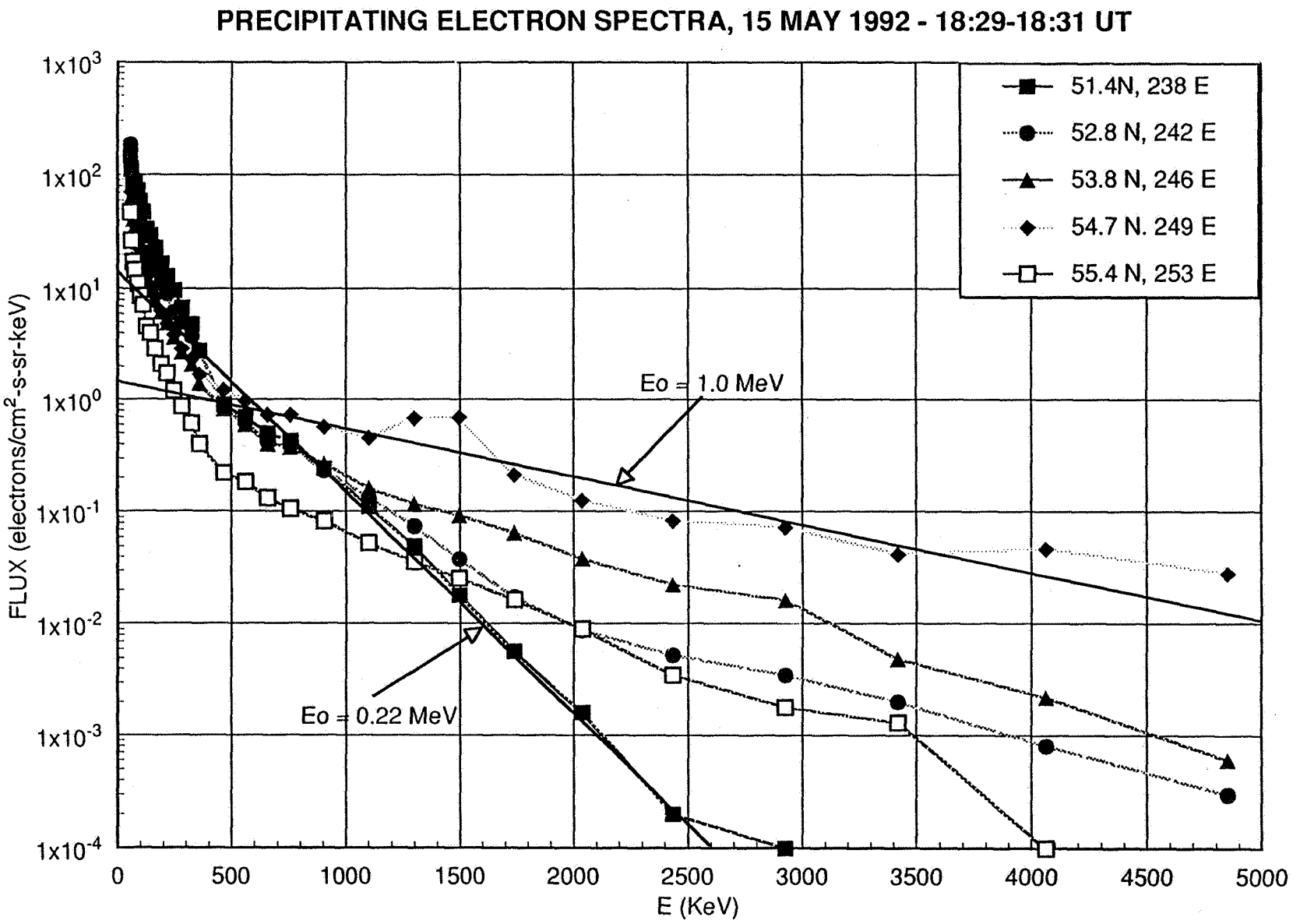


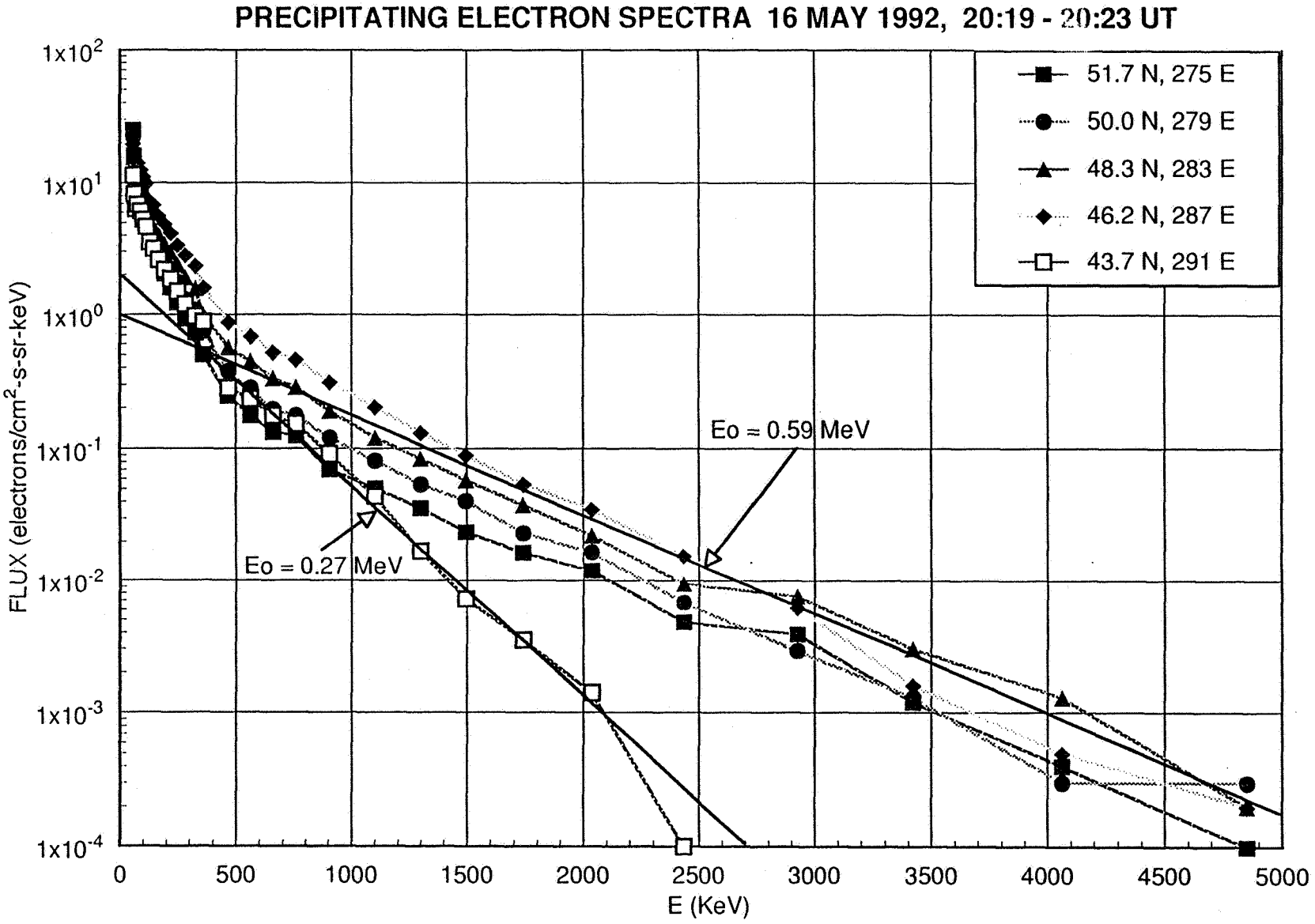

BACKGROUND ELECTRON SPECTRA, 9 NOV. 1991 & MAY 1992
FLUX (electrons/cm2-s-sr-keV)
1x10^2
1x10^1
1x10^0
1x10^-1
1x10^-2
1x10^-3
1x10^-4
0
500
1000
1500
2000
2500
3000
3500
E (keV)
Eo = 56 keV
Eo = 262 keV
Eo = 0.95 MeV
13:45 UT
9 NOV.91
00:31 UT
8 MAY 92
00:37 UT
9 MAY
00:40 UT
10 MAY

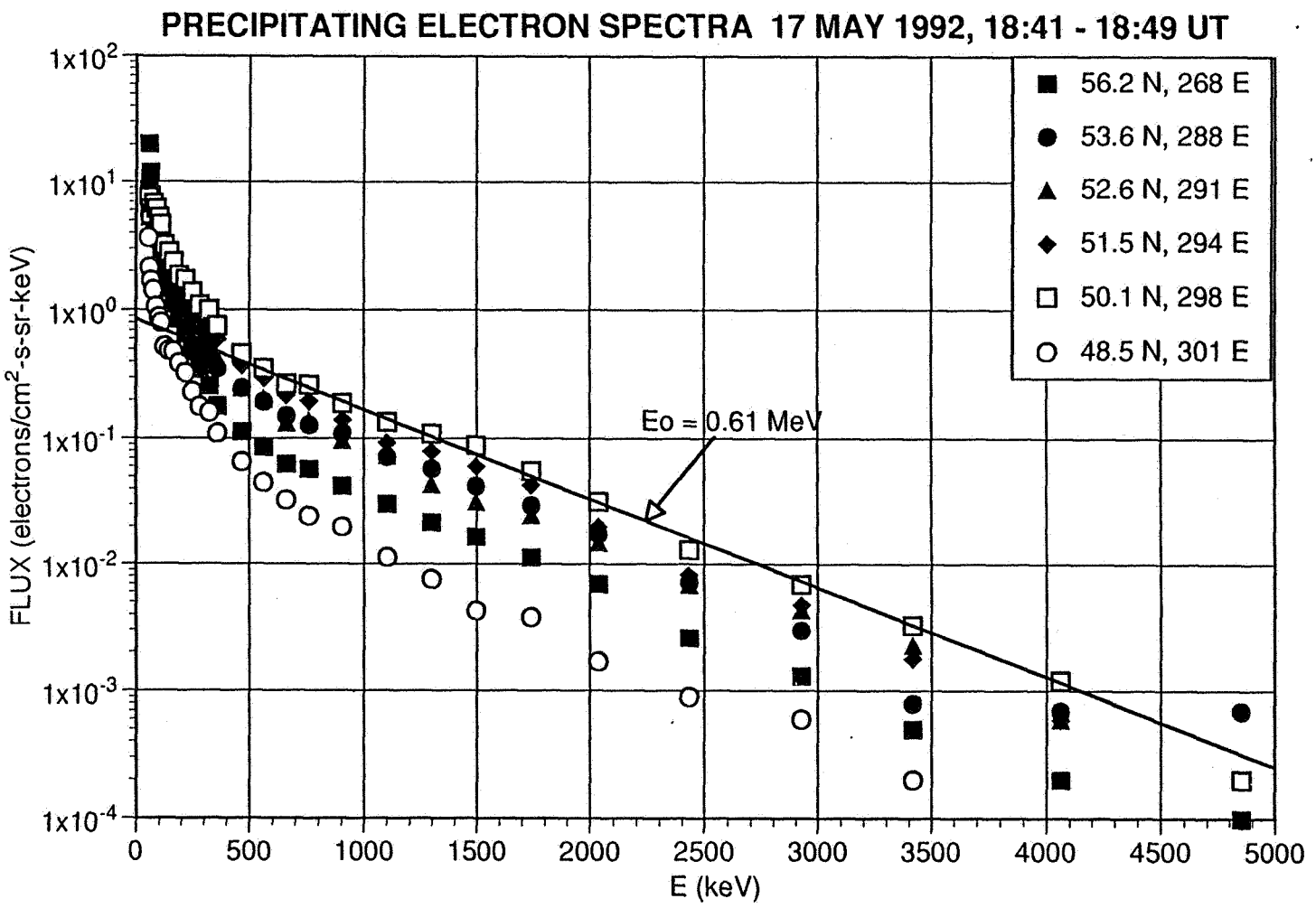

PRECIPITATING ELECTRON SPECTRA, 12 MAY 1992
FLUX (electrons/cm2-s-sr-keV)
1x10^3
1x10^2
1x10^1
1x10^0
1x10^-1
1x10^-2
1x10^-3
1x10^-4
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
E (MeV)
00:48 UT
00:51 UT
23:12 UT
23:14 UT
56.7 N, 201 E
54.4 N, 220 E
56.2 N, 203 E
56.9 N, 214 E
Eo = 357 keV
Eo = 275 keV

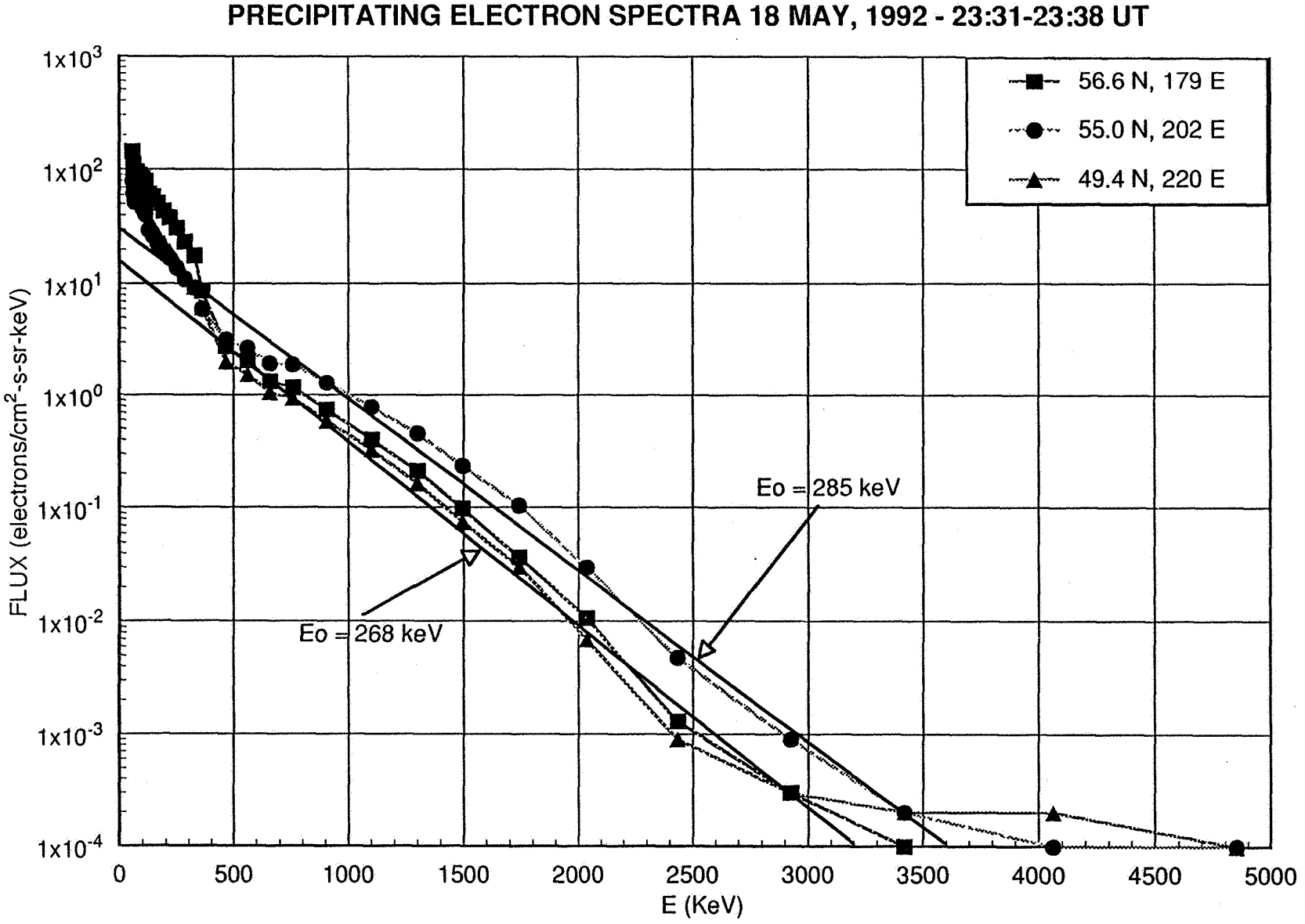

PRECIPITATING ELECTRON SPECTRA 13 MAY 1992, 23:14 - 23:26 UT
FLUX (electrons/cm²-s-sr-keV)
1x10³
1x10²
1x10¹
1x10⁰
1x10⁻¹
1x10⁻²
1x10⁻³
1x10⁻⁴
0
500
1000
1500
2000
2500
3000
3500
4000
4500
E (KeV)
Eo = 0.34 MeV
Eo = 0.21 MeV
55.0 N, 189 E
56.6 N, 191 E
56.8 N, 214 E
54.2 N, 233 E
49.2 N, 249 E
44.9 N, 258 E

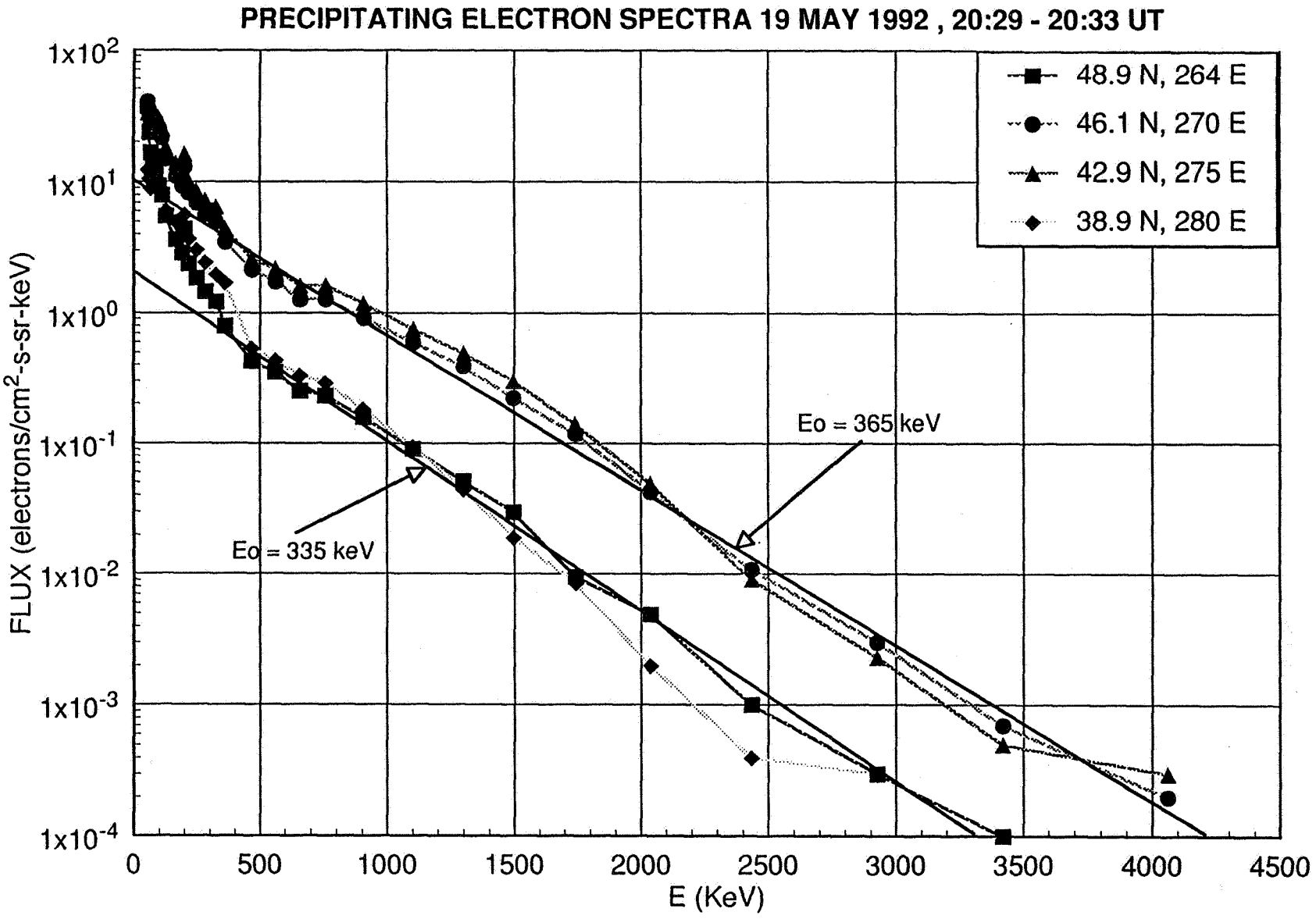

PRECIPITATING ELECTRON SPECTRA 14 MAY, 1992 - 21:40-21:52 UT
FLUX (electrons/cm²-s-sr-keV)
1x10³
1x10²
1x10¹
1x10⁰
1x10⁻¹
1x10⁻²
1x10⁻³
1x10⁻⁴
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
E (keV)
55.1 N, 208 E
56.3 N, 217 E
56.8 N, 224 E
56.9 N, 232 E
54.8 N, 249 E
50.8 N, 264 E
48.4 N, 270 E
45.9 N, 274 E
Eo = 1.4 MeV
Eo = 208 keV

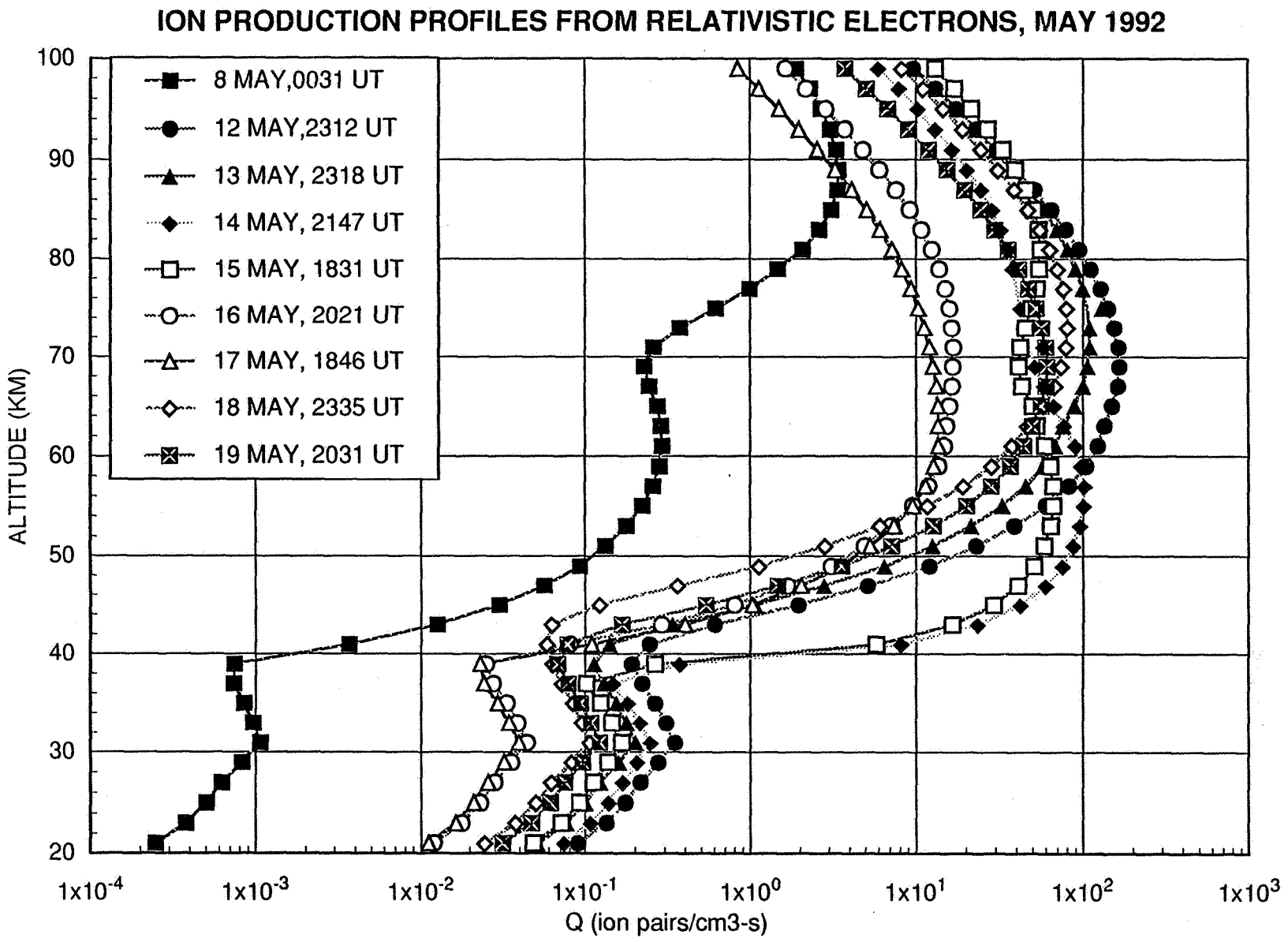

PRECIPITATING ELECTRON SPECTRA, 15 MAY 1992 - 18:29-18:31 UT
FLUX (electrons/cm²-s-sr-keV)
1x10³
1x10²
1x10¹
1x10⁰
1x10⁻¹
1x10⁻²
1x10⁻³
1x10⁻⁴
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
E (KeV)
51.4N, 238 E
52.8 N, 242 E
53.8 N, 246 E
54.7 N. 249 E
55.4 N, 253 E
Eo = 1.0 MeV
Eo = 0.22 MeV


PRECIPITATING ELECTRON SPECTRA 16 MAY 1992, 20:19 - 20:23 UT
51.7 N, 275 E
50.0 N, 279 E
48.3 N, 283 E
46.2 N, 287 E
43.7 N, 291 E
Eo = 0.59 MeV
Eo = 0.27 MeV
FLUX (electrons/cm²-s-sr-keV)
1x10²
1x10¹
1x10⁰
1x10⁻¹
1x10⁻²
1x10⁻³
1x10⁻⁴
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
E (KeV)


PRECIPITATING ELECTRON SPECTRA 17 MAY 1992, 18:41 - 18:49 UT
56.2 N, 268 E
53.6 N, 288 E
52.6 N, 291 E
51.5 N, 294 E
50.1 N, 298 E
48.5 N, 301 E
Eo = 0.61 MeV
FLUX (electrons/cm²-s-sr-keV)
E (keV)
1x10²
1x10¹
1x10⁰
1x10⁻¹
1x10⁻²
1x10⁻³
1x10⁻⁴
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000


PRECIPITATING ELECTRON SPECTRA 18 MAY, 1992 - 23:31-23:38 UT
56.6 N, 179 E
55.0 N, 202 E
49.4 N, 220 E
Eo = 285 keV
Eo = 268 keV
FLUX (electrons/cm2-s-sr-keV)
E (KeV)
1x10^3
1x10^2
1x10^1
1x10^0
1x10^-1
1x10^-2
1x10^-3
1x10^-4
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000


PRECIPITATING ELECTRON SPECTRA 19 MAY 1992 , 20:29 - 20:33 UT
48.9 N, 264 E
46.1 N, 270 E
42.9 N, 275 E
38.9 N, 280 E
Eo = 365 keV
Eo = 335 keV
FLUX (electrons/cm2-s-sr-keV)
1x10^2
1x10^1
1x10^0
1x10^-1
1x10^-2
1x10^-3
1x10^-4
0
500
1000
1500
2000
2500
3000
3500
4000
4500
E (KeV)


ION PRODUCTION PROFILES FROM RELATIVISTIC ELECTRONS, MAY 1992
8 MAY,0031 UT
12 MAY,2312 UT
13 MAY, 2318 UT
14 MAY, 2147 UT
15 MAY, 1831 UT
16 MAY, 2021 UT
17 MAY, 1846 UT
18 MAY, 2335 UT
19 MAY, 2031 UT
ALTITUDE (KM)
100
90
80
70
60
50
40
30
20
1x10-4
1x10-3
1x10-2
1x10-1
1x100
1x101
1x102
1x103
Q (ion pairs/cm3-s)

NASA National Aeronautics and Space Administration

Report Documentation Page

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14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

Periods of highly relativistic electron precipitation have been identified from the data set of the PEM/HEPS instrument aboard UARS. The largest and most intense events of 1991 and 1992 have been analyzed to produce precipitating electron spectra and altitude profiles of ion production rate in the mesosphere.

17. Key Words (Suggested by Author(s))

mesosphere; relativistic electrons; electron precipitation; ion production; UARS; PEM; HEPS

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